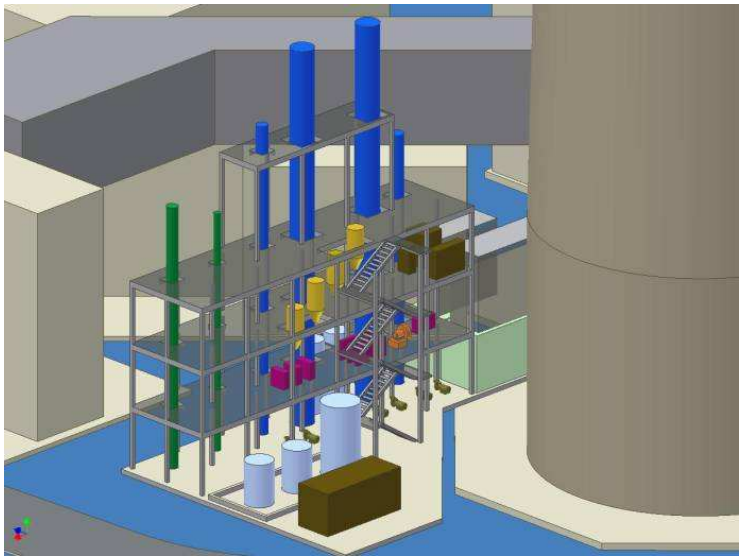
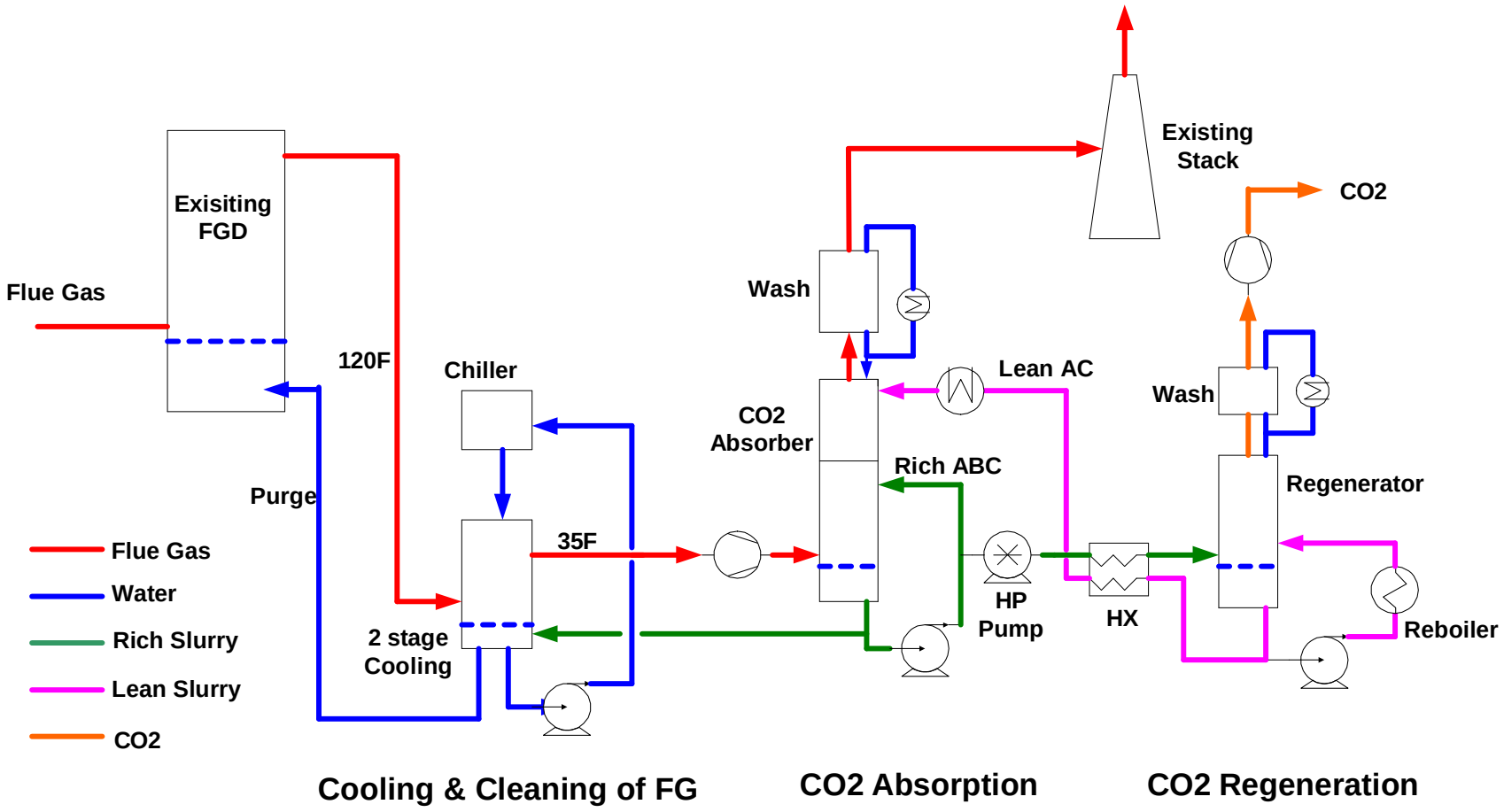


Chilled Ammonia Process Update

Richard Rhudy, EPRI
Sean Black, ALSTOM
CO_2 Capture Network
May 24, 2007
Lyon, France

Schematic of the Chilled Ammonia Process



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Advantages of Ammonia

- Energy efficient capture of CO_2
- High capacity for CO_2 per unit of solution
- High pressure regeneration
- Low heat of reaction
- Low cost reagent
- No degradation during absorption-regeneration
- Tolerance to oxygen and contaminants in gas

Ammonia Process Innovations

- Cooling the flue gas to 0-10^{o}C
  - Condensing H_2O and eliminating residual contaminants
  - Reducing flue gas volume and increasing CO_2 concentration
- Operating the absorber at 0-10^{o}C for high CO_2 capture efficiency with low NH_3 emission
- Regeneration at >120^{o}C and >20 bar to generate high pressure CO_2 stream with low moisture and ammonia concentration

Chilled Ammonia Scrubber Development Program

- Step 1 – Small bench scale testing at SRI International
  - Work co-funded by ALSTOM, EPRI and Statoil
- Step 2 – Large bench scale testing at SRI International
  - Work co-funded by ALSTOM, EPRI and Statoil
- Step 3 – Field pilot testing at We Energies
  - Work co-funded by ALSTOM and EPRI
- Step 4 – Commercial Demonstration at AEP Mountaineer

Step 1 – Small Bench Scale Testing
Key Objectives

- Establish thermodynamic potential
  - Testing of absorber and regenerator
- Generate data to support initial techno-economic analysis
- Identify key issues to be addressed in later development stages

Small Bench Scale Testing
Picture of Absorber System

Small Bench Scale Testing
10” D, 6ft H, Bubbler reactor

Small Bench Scale Testing
Techno-Economic Analysis

	Supercritical PC Without CO_2 Removal	SCPC With MEA CO_2 Removal Parsons Study	SCPC With NH_3 CO_2 Removal Current Study
Total power plant cost, M$	528	652	648
Coal Feed rate, lb/hr	333,542	333,542	333,542
Coal heating value, Btu/lb (HHV)	11,666	11,666	11,666
Boiler heat input, MMBtu	3,891	3,891	3,891
LP Steam extraction, lb/hr for reboiler	0	1,215,641	179,500
Steam Turbine Power, kWe	498,319	408,089	478,319
Generator loss, kWe	(7,211)	(5,835)	(7,018)
Gross plant, kWe	491,108	402,254	471,301
Plant Auxiliary Load (IDF, FGD, BFW pumps, Water pumps, Cooling Towers, CO2 unit, Chillers, CO2 compressor, BOP), kWe	(29,050)	(72,730)	(56,050)
Net Power Output	462,058	329,524	415,251
Avoided Cost, $/ton CO2	Base	51.1	19.7

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Step 2 - Large Bench Scale Testing
Key Objectives

- Demonstrate potential to achieve 90% CO_2 capture efficiency for 3.5, 8, 15% CO_2 concentrations
- Demonstrate low ammonia emission
- Measure mass transfer
- Optimization of absorber design and operating conditions
- Provide data to support the design of the 5 MW pilot

Large Bench Scale Testing
Process Flow Diagram for Absorber System

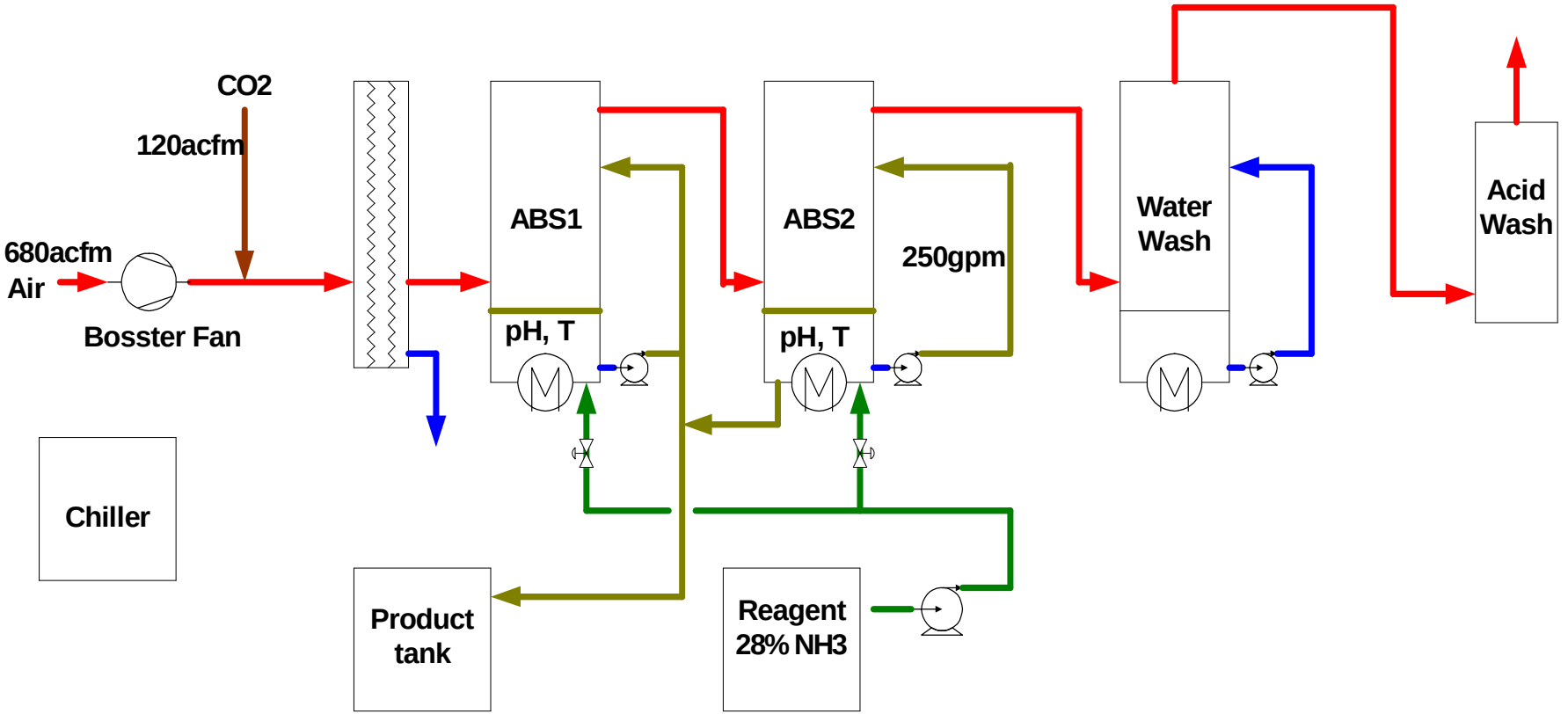

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Photo of the Absorber and Water Wash System

Absorber #1 Column

Absorber #2 Column

Water Wash Columns

Air Blower

Absorber #1 Reservoir

Absorber #2 Reservoir

Water Wash #1 Reservoir

Water Wash #2 Reservoir

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Large Bench Scale Testing
Photo of the CO2 Gas Delivery System

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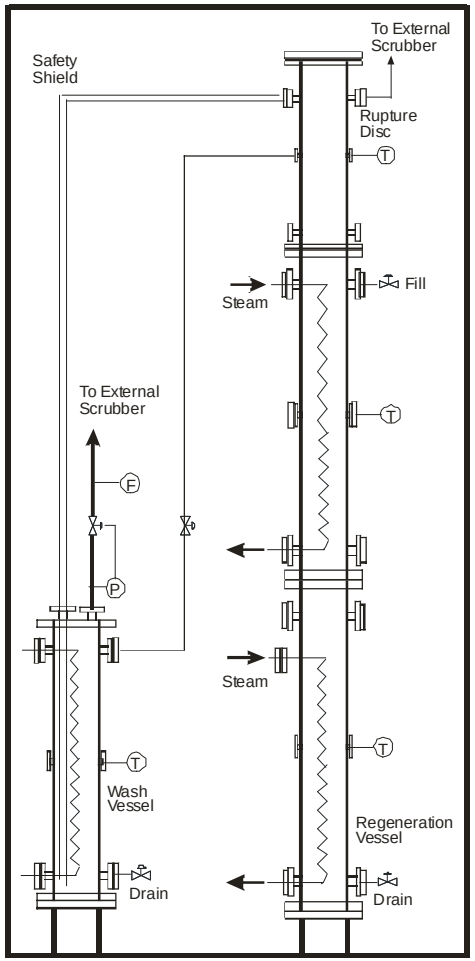
Large Bench Scale Testing
Photos of Chiller and Dry Condensing System

Large Bench Scale Testing
Key Conclusions of Absorber Testing

- Rate of CO_2 absorption/mass transfer is acceptable
- Absorber operates at low recycle rate and low pressure drop
- Generated bicarbonate solids are easy to handle
  - No fouling or scaling has been observed
- NH_3 emission from absorber is acceptable
  - Agrees well with equilibrium modelling
- Water wash performance is good
  - Low NH_3 emissions are obtained
  - Acid wash reduces emission to extremely low levels

Large Bench Scale Testing
Schematic and Photo of the Batch Regeneration System



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Step 3 - Field Pilot at We Energies
Key Objectives

- Validate operation of the entire system on actual flue gas
- Measure heat of reaction to compare against theoretical values
- Develop and evaluate the process control logic and operating system
- Operate the system in long-term tests to identify O&M issues and establish system reliability
- EPRI to develop a techno-economic analysis to scale up the system for commercial applications

Field Pilot at We Energies
Project Summary

we energies

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Field Pilot at We Energies
Proposed Pilot Location

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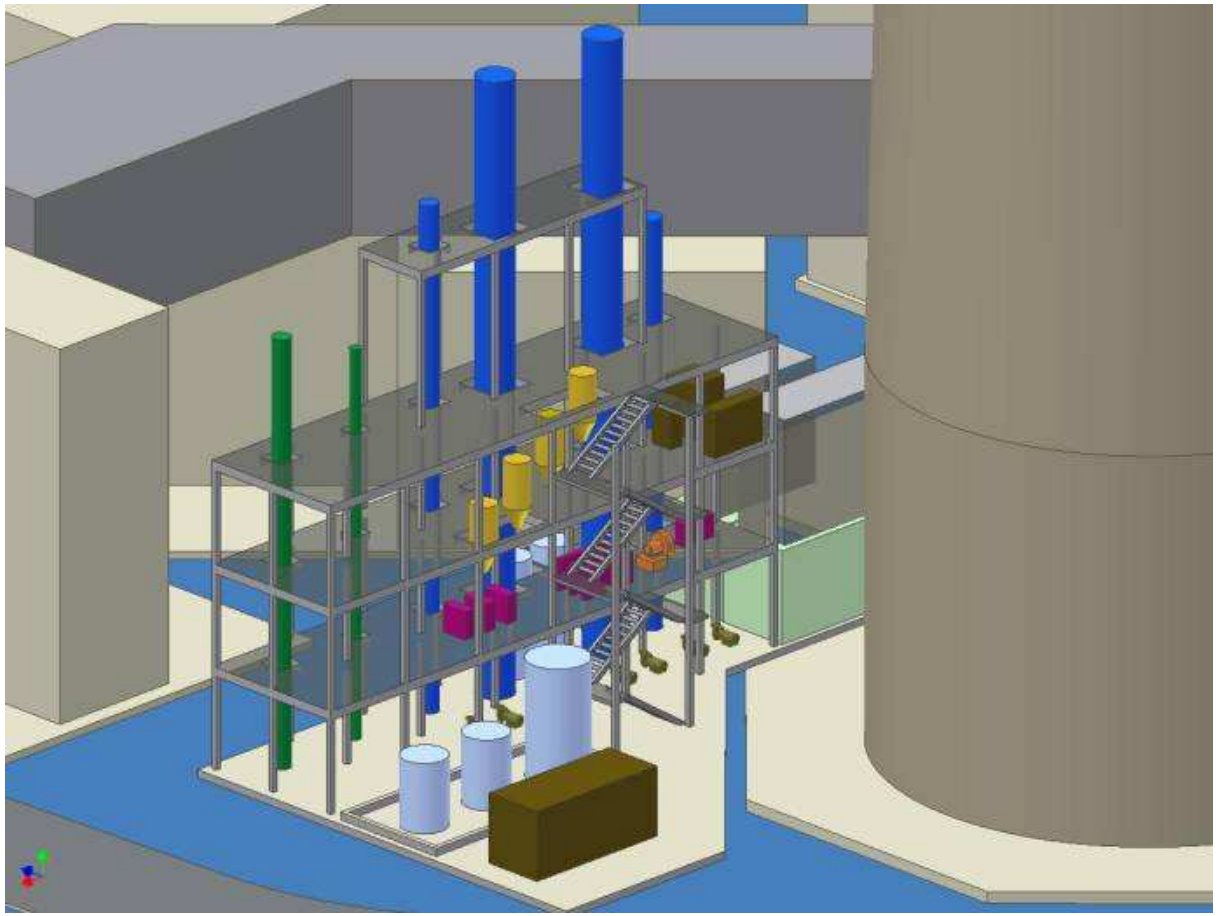
Field Pilot Duct Tie-In Locations on Unit 2

Field Pilot at We Energies
3-D View of Proposed Pilot



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Questions

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